

 Mission Research Corporation

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**FIBER OPTICALLY COUPLED EYESAFE
LASER THREAT WARNING SYSTEM**

11 MAY 2000

**MSS SPECIALTY GROUP ON INFRARED
COUNTERMEASURES**

NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA

PRESENTED BY: DR. AL TORRES

MISSION RESEARCH CORPORATION

DAYTON, OHIO 45430



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Mission Research Corporation under contract with the US Navy Small Business Innovative Research Phase II program has fabricated and tested an innovative laser receiver system. The receiver is capable of operating in the spectral domain between 0.5 and 1.8 microns. Sensitivity design goals were 1 milliwatt per square centimeter. The unit is 100% fiber optics coupled, that is, no active components are located within the receiver head.

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**EYE SAFE LASER THREAT WARNING SYSTEM
(ESLTWS)
PHASE II SBIR PROGRAM**



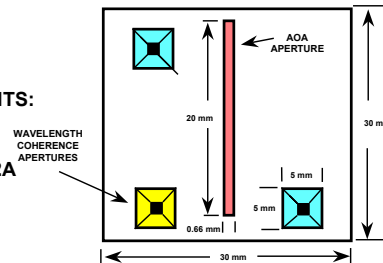
• **CONCEPT:**

- TO DEVELOP A UNIQUE AND NOVEL EYE SAFE LASER THREAT WARNING RECEIVER SYSTEM. MUST BE LIGHTWEIGHT, MUST BE CONFORMAL TO AIRCRAFT SKIN, MUST HAVE A HIGH DEGREE OF RFI/EMI IMMUNITY AND SHOULD BE LOW COST. PERFORMANCE REQUIREMENTS SIMILAR TO OR BETTER THAN THE AN/AVR-2A.

• **PRODUCT:**

- A SMALL APERTURE LASER WARNING RECEIVER, FIBER OPTIC COUPLED. STRONG POINTS:

- SAME SENSITIVITY AS AN/AVR-2A
- USES COTS PARTS AND SUBSYSTEMS
- PROJECTED LOWER COST THAN THE AVR-2A
- NO ACTIVE COMPONENTS AT THE AIRCRAFT SKIN OR APERTURE
- LOWER COST TO INSTALL AND MAINTAIN
- DETECTORS, SIGNAL PROCESSOR AND DATA COMMUNICATIONS LOCATED IN THE E-BAY OF AIRCRAFT PLATFORM
- DESIGNED FOR GROWTH POTENTIAL TO INCLUDE A HIGH SENSITIVITY LASER BEAMRIDER CHANNEL



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The receiver is a very low profile unit which is conformal to the aircraft skin. It basically has two 5 mm coherency discrimination ports, one 5 mm optical port for wavelength discrimination and a narrow slit used for angle of arrival information.

EYE SAFE LASER THREAT WARNING SYSTEM FEATURES

- THE ESLTWS REPRESENTS AN INNOVATIVE APPROACH TO LASER WARNING
- UNIQUENESS:
 - **LARGE OPTICAL SPECTRAL BANDWIDTH (0.5 TO 1.8 MICRONS)**
 - LARGE FIELD OF VIEW (+/- 45 DEGREES AZ-EL, 90 DEGREES)
 - **LARGE DYNAMIC RANGE (60-70 dB OPTICAL)**
 - ANGLE OF ARRIVAL (AOA) ACCURACIES TO +/- 1.5 DEGREES
 - MODERATE SENSITIVITY (MDS) OF 0.8 mW/cm² AT 1.54 MICRONS
 - USES FIBER OPTICS FOR HIGH IMMUNITY AGAINST EMI/RFI SOURCES
 - **UNIQUE METHOD TO GET WIDE FOV WITH FIBER OPTICS AND NO LENSES (SIMPLIFIES ALIGNMENTS)**
 - USES A MODIFIED PC TYPE COMPUTER FOR SIGNAL PROCESSING (COTS)
 - **UNIQUE CONCEPT TO MEASURE COHERENCE PROPERTIES OF INCOMING RADIATION BY SCINTILLATION VARIANTS**
 - SMALL, LIGHT-WEIGHT AND COMFORMAL SENSOR HEADS

Some of the unique and innovative properties of the receiver system.

MRC RECEIVER AND OTD WITNESS SENSOR



The ESLTWS is mounted on a tripod with a pointing scope on top. The two heads are identical in configuration and performance. One head is rotated 90 degrees to provide AOA in the elevation plane while the other provides AOA in the azimuth plane. Adjacent to the receiver head is the Office of the Test Director (OTD) ground truth/ witness sensor (radiometer). The OTD witness sensor aperture is not much larger than the ESLTWS aperture thus is also very susceptible to scintillation variations.

MRC EMBEDDED PC TYPE COMPUTER AND POWER SUPPLY



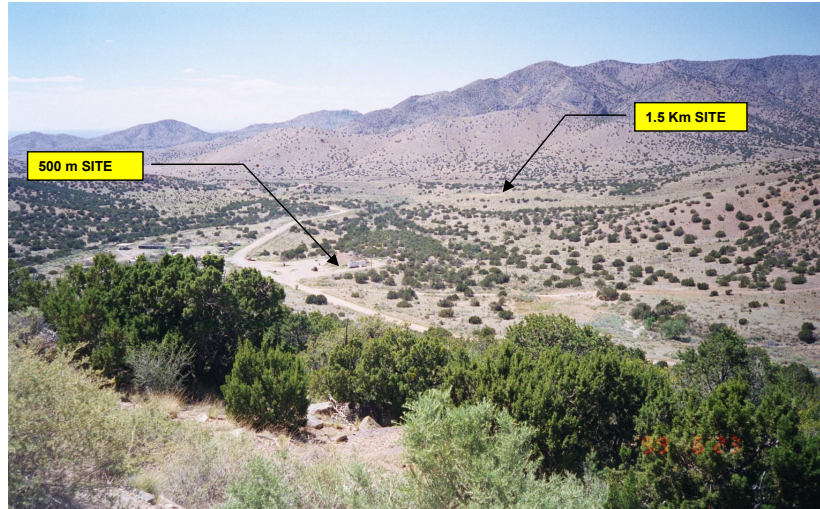
MRC ESLTWS processing and embedded computer with a power supply in the lower part of the 19 inch rack. The computer used for demonstrating the performance of the unit was fabricated by Ziatec.

MRC DATA LOGGING COMPUTER AND MIL-STD-1553 CONTROLLER EMULATOR



The logging computer and the 1553 bus controller was implemented with the use of a luggable computer. Communications with the embedded computer was done with the use of a 1553 bus network to provide a realistic aircraft representation.

SANDIA RANGE TEST SITE
LOOKING DOWN TO LASER SOURCE LOCATIONS (500 m & 1.5 Km)



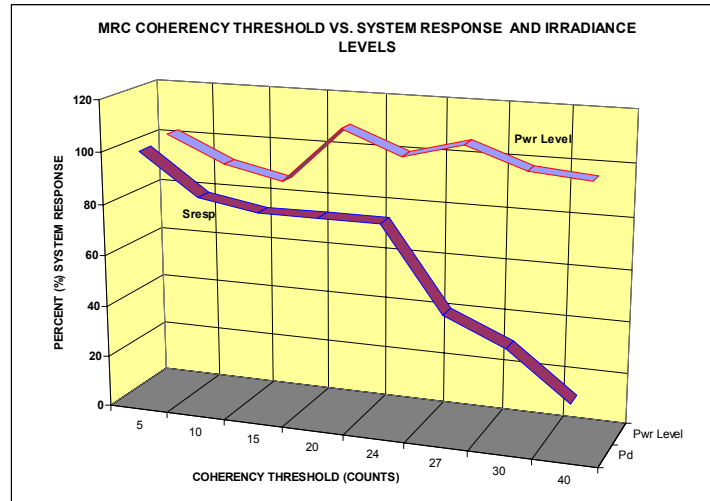
Picture of the two laser sites, one at 500 meters and the other at 1500 meters. The NRL scintillometer was located at the 500 meters site. Elevation between the sites was approximately 300 feet.

FIELD TEST RESULTS

- COHERENCE DISCRIMINATION LEVELS OF 24 COUNTS WERE SUFFICIENT TO PREVENT LASER DETECTION FROM RADIO SIGNALS, XENON STROBES (SHORT RANGE) AND LONG RANGE POWERFUL STROBES (MIR). ESSENTIALLY, NO FALSE SIGNALS TRIGGERED THE SYSTEM WHEN COHERENCY VALUE WAS AT THIS LEVEL.
- SCINTILLATION MEASUREMENTS DONE WITH NRL SCINTILLOMETER; SCINTILLATION MEASURED ON THE AVERAGE AT 9×10^{-13} OVER A 500 METER PATH AT A WAVELENGTH OF 0.9 MICROMETERS
- ANGULAR MEASUREMENTS WERE MADE TO DETERMINE FIELD OF VIEW OF THE SYSTEM. ANGULAR FIELD DATA MATCHES THEORETICAL RESULTS (+/- 45 DEGREES IN BOTH PLANES)
- ATMOSPHERIC SCINTILLATION AS A COHERENCY DISCRIMINATOR DETERMINED TO BE A RELIABLE METHOD. MORE FIELD DATA IS NEEDED TO PROPERLY VALIDATE THE ALGORITHMS USED.

Self explanatory.

COHERENCY THRESHOLD VS. SYSTEM RESPONSE



This chart shows the experimental curve obtained from the Sandia Field Test data reduction. It shows that for a constant power of about 100 milliwatts per square centimeter, by adjusting the coherence threshold, the percent of system response to coherent sources can be reduced accordingly. It also implies that only severe scintillation will get through the signal processor.

SANDIA FIELD TEST RESULTS

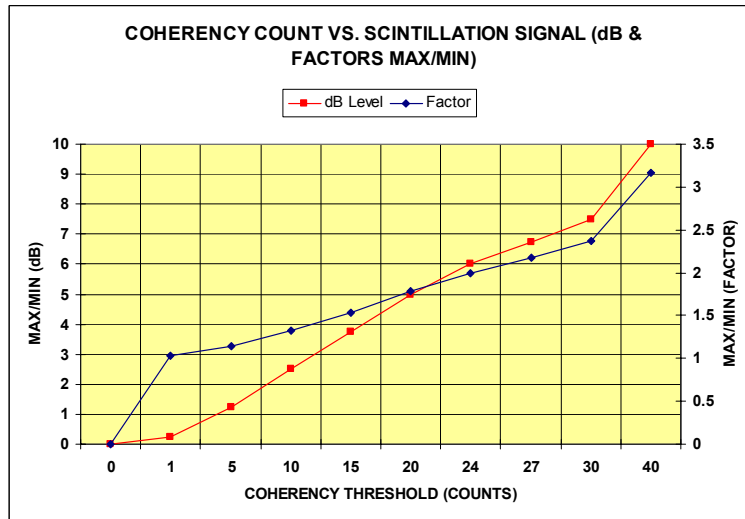
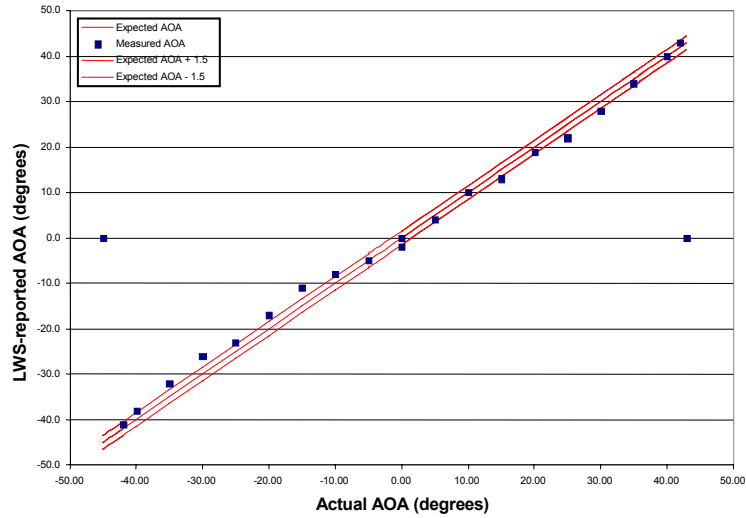


Chart shows the relationship of coherency threshold counts versus the number of decibels between a maxima and minimum among the coherence channel. It also shows the ratio of the between the peaks and the valleys generated by atmospheric scintillation.

SANDIA FIELD TEST AOA RESULTS



This chart shows the excellent AOA response of the system between -45 degrees and + 45 degrees for both azimuth and elevation.

CONCLUSIONS AND RECOMMENDATIONS

- **COHERENCY DISCRIMINATION BY THE USE OF ATMOSPHERIC VARIANTS IS A VALID PROCESS. FIELD TEST DATA DEMONSTRATED A ROBUST AND RELIABLE ALGORITHM (PATENT PENDING)**
- **LASER RECEIVER WIDE FOV CAN BE ACHIEVED WITH THE USE OF FIBER OPTICS TAPERS (PATENT PENDING)**
- **WIDE SPECTRAL COVERAGE CAN BE ACHIEVE WITH A SINGLE DETECTOR COVERING THE SPECTRAL RANGE BETWEEN 0.5 AND 1.8 MICRONS (CONTINUOUS)**
- **LARGE OPTICAL DYNAMIC RANGES (60-70 dB) DEMONSTRATED WITH LARGE TEMPORAL BANDWIDTHS**
- **RFI/EMI IMMUNITY ACHIEVED WITH 100% PASSIVE OPTICAL COMPONENT HEAD**
- **PROGRAM DEMONSTRATED HIGH USE OF COTS; POTENTIAL FOR LOWER FABRICATION COSTS.**

Self explanatory.

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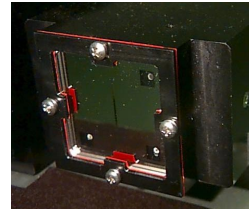
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